

Feb. 24, 1948.

P. E. MEIDENBAUER, JR

2,436,522

BREATHING APPARATUS

Filed Dec. 1, 1944

5 Sheets-Sheet 1

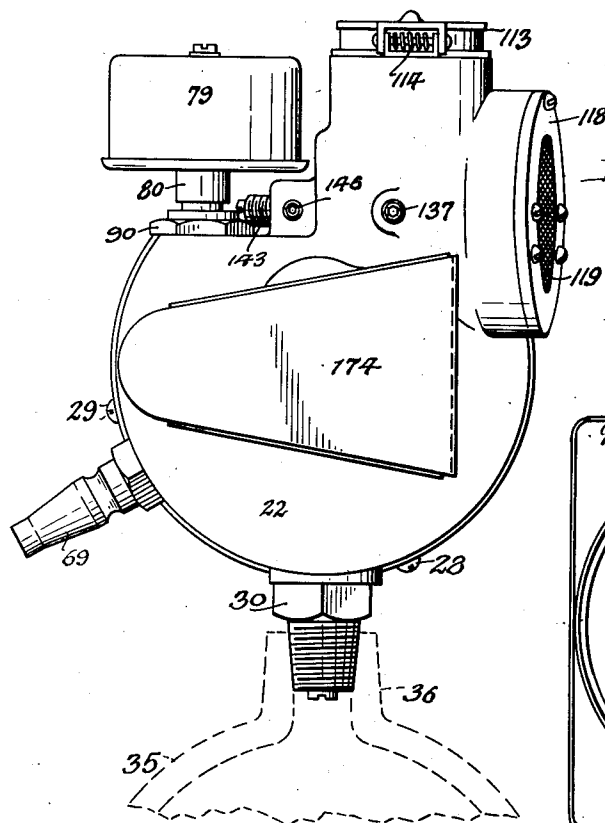


Fig. 1.

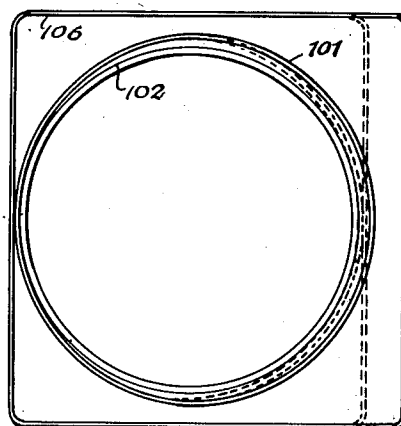


Fig. 18.

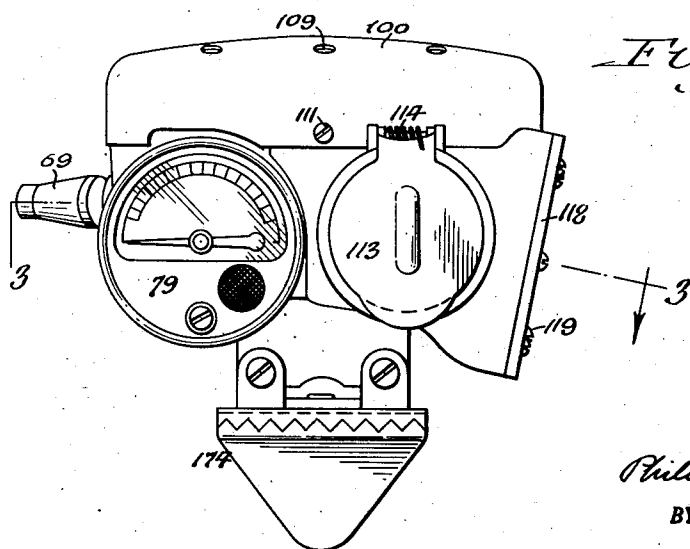


Fig. 2.

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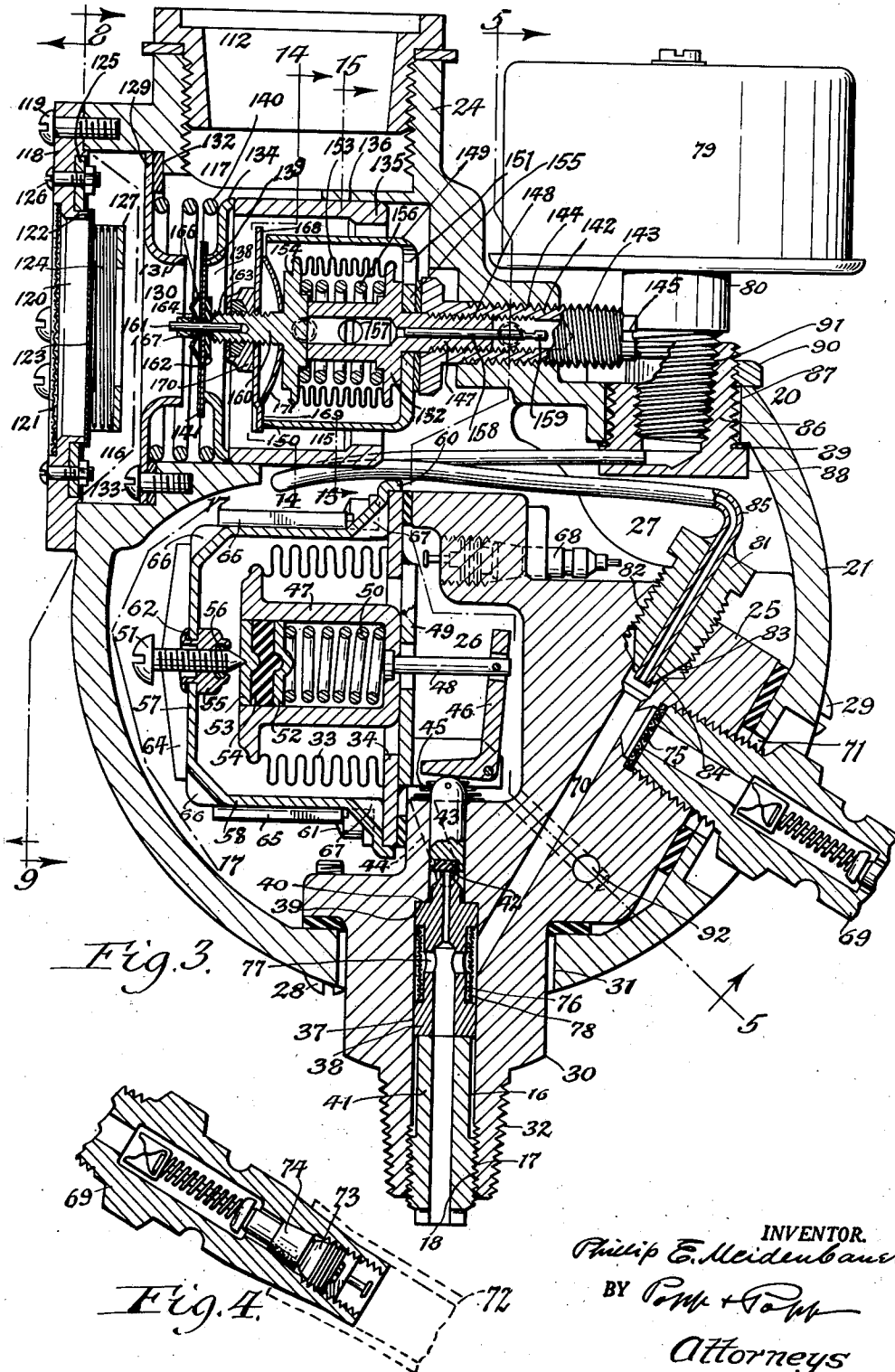
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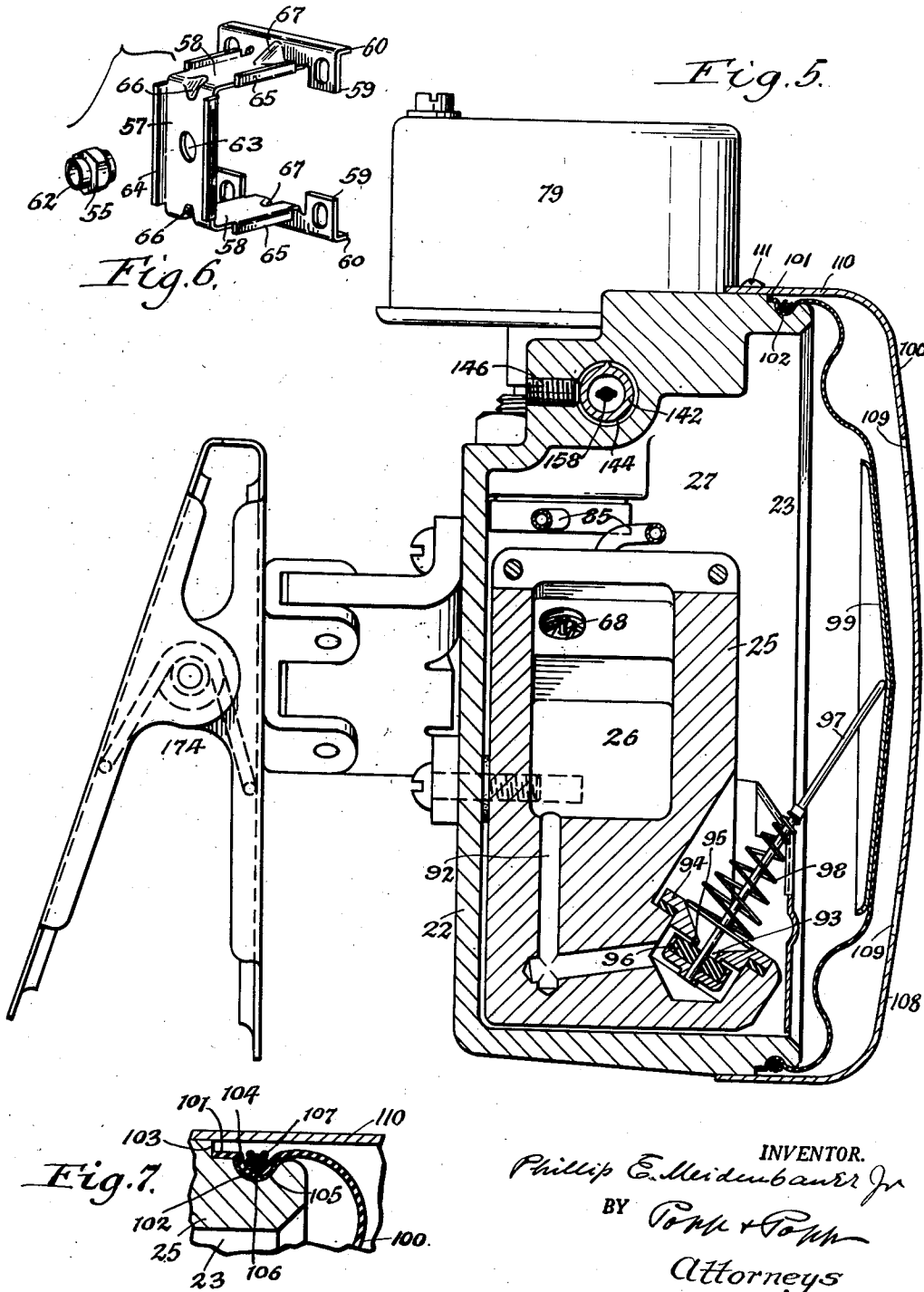
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Fig. 8.

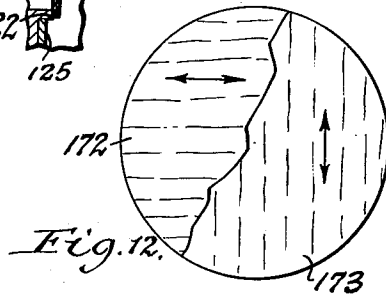
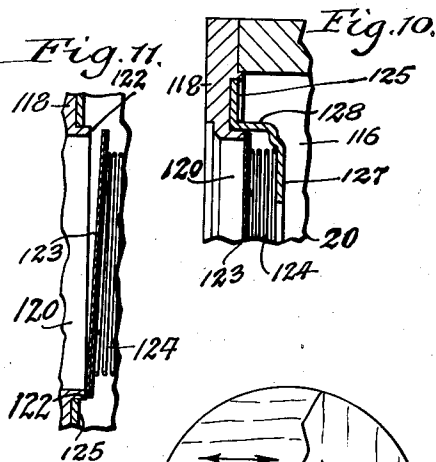
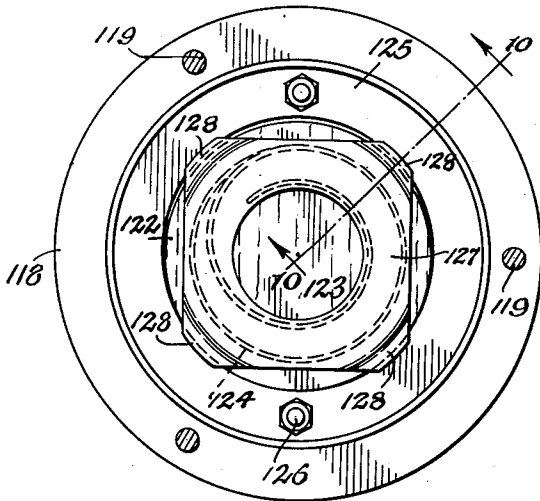


Fig. 12.

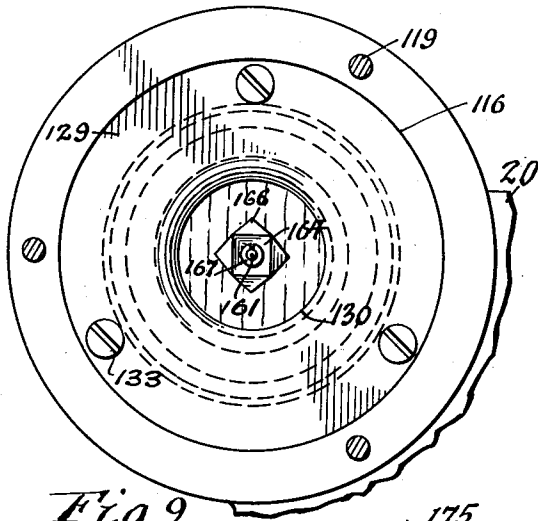


Fig. 9.

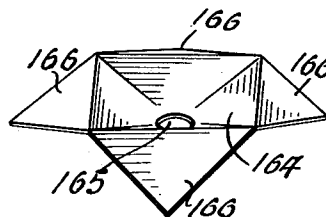


Fig. 13.

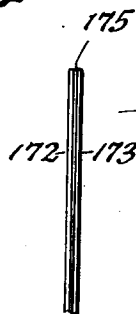


Fig. 19.

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5 Sheets-Sheet 5

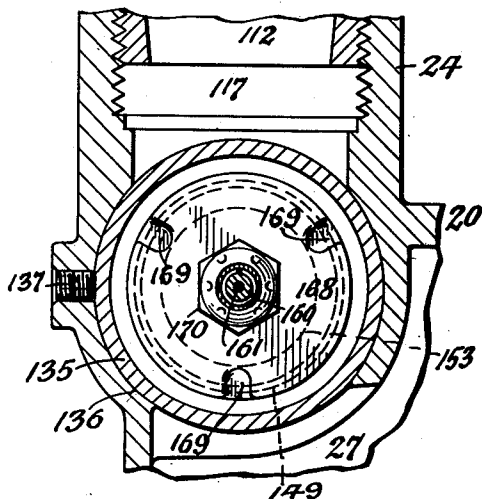


Fig. 14.

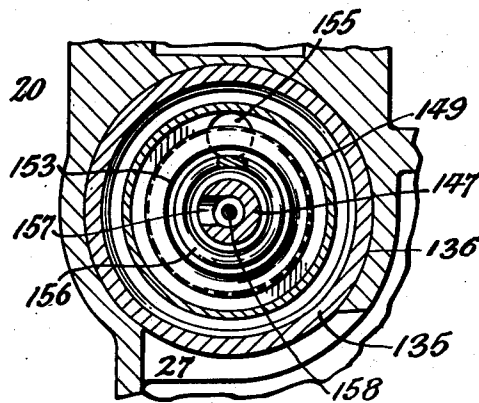


Fig. 15.



Fig. 16.

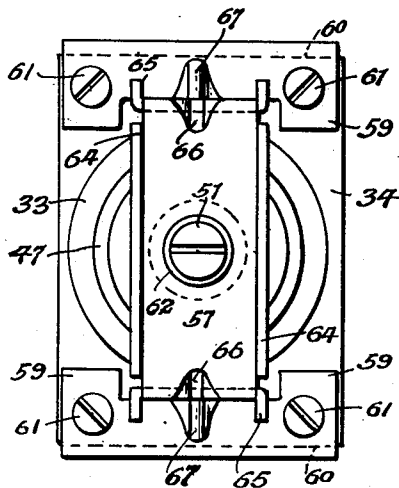


Fig. 17.

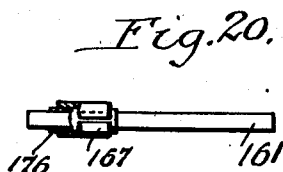


Fig. 20.

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UNITED STATES PATENT OFFICE

2,436,522

BREATHING APPARATUS

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Application December 1, 1944, Serial No. 566,080

13 Claims. (Cl. 137-153)

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This invention relates to a breathing apparatus and more particularly to an apparatus of this character whereby oxygen taken from a high pressure supply is delivered at a lower pressure to a person in response to the inhalation of the latter and which automatically varies the proportion of air and oxygen in the gas supplied to the person in accordance with the altitude at which the person is located.

The object of this invention is to provide an improved apparatus which performs these functions reliably and which can be readily adjusted so as to operate accurately at different altitudes and under varying conditions, and which can also be easily manufactured and adjusted so as to operate most efficiently.

In the accompanying drawings:

Fig. 1 is a rear elevation of the breathing apparatus embodying the improvements of this invention.

Fig. 2 is a top plan view thereof.

Fig. 3 is a vertical longitudinal section of the same, taken on line 3-3, Fig. 2.

Fig. 4 is a fragmentary section of the check valve mechanism in the oxygen supply line of this apparatus.

Fig. 5 is a vertical cross section of the apparatus, taken on line 5-5, Fig. 3.

Fig. 6 is a perspective view of the bracket and screw nut forming part of the means for adjusting the bellows diaphragm of the pressure reducing mechanism.

Fig. 7 is a fragmentary section, on an enlarged scale, showing the means for securing the diaphragm of the demand valve mechanism to the casing of the apparatus.

Fig. 8 is a vertical section, taken on line 8-8 looking outwardly.

Fig. 9 is a section taken on the same line looking inwardly.

Fig. 10 is a fragmentary section, taken on line 10-10 Fig. 8.

Fig. 11 is a fragmentary section similar to Fig. 3 but showing the air check valve opened.

Fig. 12 is a face view of the air check valve.

Fig. 13 is a perspective view of the washer engaging with the outer side of the air and oxygen proportioning valve.

Figs. 14 and 15 are fragmentary vertical sections, taken on the correspondingly numbered lines in Fig. 3.

Fig. 16 is a perspective view showing the spring washer forming part of the means for adjusting the aneroid of the air and oxygen proportioning mechanism.

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Fig. 17 is an end view of the bellows adjusting mechanism looking inwardly from line 17-17, Fig. 3.

Fig. 18 is a diagrammatic view showing the manner of securing the demand valve diaphragm to the case of the apparatus.

Fig. 19 is an edge view, on an enlarged scale, showing the manner in which the mica air check and proportioning valves are constructed.

Fig. 20 is a side view, partly in section and on an enlarged scale, showing the manner of holding the proportioning valve on its supporting pin.

In the following description similar reference numerals indicate like parts in the several figures of the drawings:

Referring to Figs. 1, 2, 3 and 5, the numeral 20 represents the main case of the apparatus which encloses the various working parts and comprises a lower part having the form of a horizontal cylindrical side wall 21 which is closed at its rear end by a vertical wall 22 and has an open front end 23, and an upper part which projects upwardly from the cylindrical wall and has the form of a tubular neck 24.

The space within the cylindrical lower part of the case is divided by a partition body 25 into a recess forming a receiving or low pressure chamber 26 into which the oxygen is conducted from a high pressure supply and a delivery chamber 27 which receives the oxygen at low pressure from the receiving chamber and supplies the same to the person being served at atmospheric or ambient pressure.

The partition body 25 is secured at its lower end and on its sides to the adjacent bottom and side parts of the case by means of screws 28, 29 so as to form gastight joints therewith and is provided on its lower end with a tubular inlet neck 30 which projects downwardly through an opening 31 in the lower part of the case wall 21 and provided with an external screw thread 32.

The partition body 25 forms the inner stationary wall of the low pressure chamber 26, the outer wall 33 of which is expansible and contractible and has the form of a bellows diaphragm which has its inner end connected with a supporting frame 34 attached to the adjacent part of the partition body so that the interior of the bellows diaphragm always communicates with the interior of the receiving or low pressure chamber 26.

The oxygen which is to be dispensed may be supplied from a relatively stationary source or a portable supply means which can be carried by the person using the apparatus. These port-

able oxygen supply means preferably comprise a portable metal container having the form of a bottle 35 provided with a tubular neck 36 the bore of which has an internal screw thread whereby the same is detachably connected with the external thread of the inlet neck 30 of the breathing apparatus. The oxygen is conducted from the container to the low pressure chamber 26 through a supply passage 37 formed in the partition body 25 and its inlet neck 36 and the movement of oxygen through this passage is controlled by a pressure reducing valve mechanism which is preferably constructed as follows:

The numeral 38 represents a valve tube arranged in the supply passage and provided on its upper part with an external upwardly facing shoulder 39 which bears against a downwardly facing shoulder 40 in the bore of the passage 37, as shown in Fig. 3. This valve tube is held in this position by a tubular clamping screw nut 41 which is screwed in the lower part of the passage 37 and bears with its upper end against the lower end of the valve tube 38. The tubular clamping nut is of such length that when the same is screwed into the passage 37 the fullest extent its lower end will project below the lower end of the coupling neck 30, whereby the latter is always maintained in its normal shape and prevented from being distorted or squeezed inwardly at its lower end across the lower end of the clamping screw nut 41 which otherwise would render it difficult to remove the latter in case this becomes necessary for inspection, cleaning or repairing. As shown in Fig. 3 only the outer part of the lock nut 41 is provided with an external screw thread 18 for cooperation with an internal thread 17 in the outer part of the bore 37 in the neck 30 while the periphery 16 of the inner part of this lock nut is of smaller diameter and unthreaded, thereby enabling this nut to be screwed into place without an undue number of rotations.

At its inner end the valve tube 38 is provided with a valve seat 42 and within the inner part of the passage 37 a reducing valve member 43 moves lengthwise for engaging and disengaging this seat and thereby close and open this passage. When this valve member is moved outwardly into engagement with the seat 42 the inward flow of gas through the valve tube 38 is arrested and when this valve member is moved inwardly away from the seat 42 gas is permitted to flow from the tube 38 into the upper part of the passage 37 and through a by-pass 44 in the body 25 into the low pressure or receiving chamber 26. The inward or opening movement of the valve member 43 is effected by the pressure of the gas aided by a spring 45 and the closing of the same is effected by actuating means which are responsive to an increase of gas pressure in the low pressure chamber.

In their preferred construction these actuating means include a bell crank lever 46 arranged in the low pressure or receiving chamber 26 and having a lower arm bearing against the inner end of the valve member 43 and a tubular plunger 47 arranged with the bellows diaphragm and having its outer end connected with the corresponding end of this diaphragm while its inner end is connected by a rod 48 with the other arm of said bell crank lever. The latter is pivoted on a bracket 49 which is secured to the bellows supporting ring 34 and extends partly across the opening of the same and also forms a stop to limit the inward movement of the plunger and the contraction of the bellows diaphragm. The

inward movement of the plunger and contraction of the diaphragm is effected by a spring 50 which is arranged in the tubular plunger and bears at its inner end against the corresponding end of the plunger.

Adjustment of the compression of this spring is effected by an adjusting screw 51 which is mounted on the body 25 of the apparatus and bears at its inner end against the outer end of the bellows spring through the medium of an inner follower 52 engaging the outer end of this spring, an outer follower 53 engaging with the inner end of the adjusting screw and a rubber cushion 54 interposed between said followers. This adjusting screw engages with a stationary screw nut 55 having an elastic locking ring 56 in its bore which engages the thread of the screw 51 and prevents the same from turning easily. This screw nut is mounted on the body of this apparatus by means of an arch piece or bracket which embodies a feature of this invention and is constructed as follows:

As a whole this supporting bracket is generally of U-shape and comprises a vertical bar or web 57 and two horizontal bars or legs 58 projecting inwardly from the opposite ends of this web. At its inner end each of the legs 58 is provided with a vertical foot 59 which is secured by screws 61 to an adjacent vertical surface of the bellows frame and to the body 25 and at its outer end each foot 59 is provided with a horizontal toe 60 which engages with the adjacent horizontal edge portion of the bellows frame 34. The adjusting nut 55 is secured to the inner side of the web of this bracket by means of a collar 62 projecting outwardly from this nut through an opening 63 in this web and having its outer end upset or riveted against the outer side of the web, as shown in Fig. 3.

For the purpose of rendering this bracket strong without making the same unduly heavy the web 57 is provided on its opposite edges with outwardly turned longitudinal stiffening flanges 64 and each of its legs is provided on its opposite edges with outwardly turned longitudinal stiffening flanges 65, as shown in Figs. 3, 6 and 17. This bracket is also rendered more rigid and maintained in angular form without liability of being distorted, this being accomplished by providing the corners between the web 57 and legs 58 of this bracket with diagonal ribs or beads 66, and also providing the corners between the legs and feet of this bracket with diagonal ribs or beads 67, as shown in Figs. 3, 6 and 17. These strengthening or stiffening ribs are preferably formed on this bracket by displacing part of the metal of the same at each of these corners from one side toward the opposite side of the bracket so as to effectively brace these members relative to each other and prevent displacement of the same when under stress.

Whenever the bellows 19 is expanded the requisite extent by the pressure of the gas within the receiving chamber 26 rising to a predetermined point, the reducing valve member 43 is closed and when the pressure in the receiving chamber again drops below a predetermined normal then this valve member is permitted to open for resuming the flow of gas from the supply source into the receiving chamber.

For the purpose of preventing excess pressure in the receiving chamber 26 a safety or automatic blow-off valve 68 is provided which is mounted on the body and extends from the receiving chamber 26 to the delivery chamber 27, whereby gas

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will be permitted to escape from the receiving chamber to the delivery chamber in case the pressure rises above the normal in the receiving chamber due to leakage.

Means are provided for replenishing the portable bottle 35 or delivering gas from a relatively stationary high pressure source of supply directly to the receiving chamber, which replenishing means are preferably constructed as follows:

The numeral 69 represents the body of a check valve which is secured to the side of the apparatus body 25 and communicates at its inner end with the main gas passage 37 by a branch restoring passage 70 formed in the main body 25, as shown in Fig. 3. This check valve body projects outwardly through an opening 71 in the case and is adapted to be connected by a supply hose 72, or the like, with a tank or reservoir in which a large volume of oxygen gas is stored. This check valve body is provided with an inwardly facing seat 73 with which a check valve member 74 is adapted to cooperate for permitting gas to flow inwardly to the breathing apparatus but preventing backward movement of the same.

Between the inner end of the check valve body 69 and the main body 25 a screen 75 is arranged which prevents any large particles which may be in the gas from reaching the breathing apparatus.

The lower end of the branch passage 70 opens into the side of the main gas conduit 37 and the adjacent part of the valve tube 38 is reduced in diameter, as shown at 76, so as to form an annular passage between this tube and the bore of the passage 37 which communicates with the branch passage 70. One or more openings 77 extend radially from the bore of the valve tube 38 to the periphery of its reduced part 76, whereby gas is conducted from the branch passage 70 and the annular passage formed by this reduced part to the inside of the valve tube 38 preparatory to entering the receiving chamber 26.

In the annular passage formed by the reduced part 26 of the valve tube is arranged a fine cylindrical screen 78 which further holds back any dust or like particles in the gas and prevents the same from reaching the interior of the breathing apparatus.

On top of the case is mounted a gage 79 which indicates the pressure of the gas supplied to the apparatus. This gage may be of any suitable construction and provided on its underside with a tubular neck 80 which is mounted on the case and connected with the gas supply as follows:

The numeral 81 represents a screw threaded body coupling plug which engages with an internally threaded enlargement 82 of the upper end of the branch passage 70 and has its lower end provided with a downwardly tapering conical face 83 which engages with an annular shoulder 84 between the lower small part of the branch passage 70 and the upper enlarged part 82 of the same, thereby forming a leak-tight joint between these members. The numeral 84 represents a flexible gage tube of copper or the like whereby gas is conducted from the branch passage 70 to the gage 79. This tube is arranged within the upper part of the delivery chamber 27 and has its lower end secured in the body coupling plug 81. The upper end of the gage tube is secured to the inner end of an externally threaded gage coupling plug 86 which latter is arranged in an unthreaded opening 87 in the upper part of the case and provided on its in-

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ner end with a collar 88 which bears against a packing 89 interposed between this collar and the inner side of the case. At its outer end this gage coupling plug is provided with a clamping screw nut 90 bearing against the outer side of the case, thereby producing a gas-tight joint between these members, as shown in Fig. 3. The bore of this gage coupling plug 86 is provided with an internal screw thread 91 which receives the externally threaded neck 80 of the gage. By these means the gage tube may be permanently connected as a unit with its coupling plugs 81, 86 and readily assembled as such with the case, body and gage of the apparatus and also disconnected therefrom for inspection, repairing and adjustment.

When this apparatus is in use oxygen is withdrawn from the delivery chamber 27 by the person to whom the gas is supplied by a mask which is connected with the apparatus by means which include a respiration hose. As the gas in the delivery chamber is depleted the same is replenished automatically by a demand valve mechanism which is constructed as follows:

The numeral 92 represents a demand gas passage formed in the partition body 25 and opening at its inlet end into the receiving chamber 26 and provided at its outlet with a port 93 which opens into the delivery chamber 27 and is formed in a valve plate 94 secured to the body 25, as shown in Fig. 5.

A valve seat 95 is formed on the inner side of this valve plate around the port 93 and this seat is engaged by a rocking demand valve member 96 which closes the port 93 when it engages all parts of this seat around the port but opens the latter when this valve is tilted and one part thereof turns as a fulcrum on the plate 94 while the diametrically opposite part of the same moves away from this plate.

On its outer side the demand valve 96 is secured to the inner end of an inclined valve stem 97. The latter terminates at its outer end in the central part of the delivery chamber and is normally held in a position in which the demand valve is closed by a conical spring 98 connected at its outer end to this valve stem and bearing at its inner end against the valve plate 94. The outer or free end of the valve stem rests against a bearing plate or disk 99 supported on the central body part 100 of a diaphragm which extends across the outer end of the opening 23 of the delivery chamber and is expanded and contracted by the increase and decrease of the volume or pressure of the gas in the delivery chamber. As the pressure of the gas in the delivery chamber reaches normal the diaphragm is expanded to such an extent that it permits the spring 98 to close the demand valve 96 and as the gas is withdrawn from this chamber and the pressure within the latter is reduced below normal the atmospheric pressure against the outer side of the latter contracts the same and causes the demand valve to be opened and resume the flow of gas from the receiving chamber 26 into the delivery chamber 27.

The body 100 of the diaphragm is provided with an annular flange 101 which surrounds the periphery of the case around the opening 23 thereof and extends over an annular groove 102 in this periphery and abuts at its inner edge against an annular shoulder 103 formed on this periphery adjacent to the inner side of said groove, as shown in Figs. 5 and 7. This flange of the demand valve diaphragm has a bead 104 de-

deflected into the groove 102 and secured therein by means which include a thin film 105 of cement interposed between said groove and the inner side of said bead, an elastic band 106 which surrounds the outer side of said bead and holds the same in an inwardly deflected position in said groove, and a strong fine thin thread 107 which is wound around the outer side of said bead and engages the adjacent part of said band for retaining the same in position.

The preferred method of assembling the demand valve diaphragm and the case of the breathing apparatus is preferably as follows:

The thin film of cement 105 is first placed in the groove 102 and left to dry a sufficient length of time to render the cement tacky. Then the flange 101 of the demand valve diaphragm is fitted tightly around the periphery of that part of the case which surrounds the opening 23 and its inner edge is engaged with the shoulder 103 thereof, as shown in Figs. 5 and 7. Thereafter the elastic band 106 is expanded to a diameter greater than the periphery of the case around the opening 23 and passed inwardly around this periphery. Then one part of this band, say the left hand part, is engaged with the outer side of the diaphragm flange 101 over the corresponding part of the groove 102 so as to cause this part of the flange to be deflected into said groove while the remaining parts of said band remain out of engagement with said flange, as shown by full lines in Fig. 18. The diametrically opposite, or right hand, part of the band is then permitted to contract into engagement with the outer side of the corresponding part of the diaphragm flange so as to draw the latter into the adjacent part of the groove 102 while the upper and lower parts of this band are still out of engagement from this flange, as shown by dotted lines in Fig. 18. The upper and lower parts of the band are then released either successively or simultaneously, this permitting the same to contract and draw the upper and lower parts of the diaphragm flange into the corresponding parts of the case groove 102. If at this time there are any wrinkles in this diaphragm the same are removed by the assembler drawing on the diaphragm in the proper direction to smooth out the wrinkles, this being possible due to the adhesive effect of the cement 106 being still sufficiently weak at this time to permit this smoothing operation. After the cement has dried the strong thin thread 107 is wound around the outer side of the bead or deflected part of the diaphragm flange and the adjacent part of the elastic band and tied in place, thereby retaining the parts reliably in their assembled position.

In order to protect the demand valve diaphragm a cover is provided having a disk shaped part or head 108 arranged along the outer side of the diaphragm and provided with one or more air openings 109 and a marginal flange 110 which surrounds the peripheral part of the case around its opening 23 and is secured thereto beyond the inner edge of the diaphragm flange 101 and the case shoulder 103 by screws 111.

The tubular neck 24 of the apparatus is provided with an outlet socket 112 through which air, or oxygen, or a mixture of air and oxygen are delivered from the apparatus to the person being served by a mask and a hose having its inlet end provided with a tube which is inserted in the socket 112 and its outlet end connected with said mask. These means are of well-known and usual construction and therefore not shown

in the drawings. When the apparatus is not in use the outlet socket 112 is closed by a lid or cover 113 pivoted on this socket and yieldingly held in a closed position by a spring 114, as shown in Figs. 1 and 2.

Proportioning means are provided for conducting to the wearer of the mask either oxygen only taken from the chamber 27, when the apparatus is used by aviators flying at extremely high altitudes, or ordinary air exclusively or nearly exclusively when the apparatus is used on the ground or at low levels, or a mixture of oxygen and ordinary air when the apparatus is used at moderately high altitudes.

The proportioning means for this purpose shown in Figs. 1, 2, 3 and 8-16 are constructed as follows:

The numeral 115 represents an oxygen chamber which communicates constantly with the delivery chamber 27. The numeral 116 represents an air chamber which is adapted to be connected with and disconnected from the outer atmosphere and 117 an outlet or respiration chamber which communicates constantly with the outlet socket 112 of the apparatus and is adapted to be connected either solely or nearly so with the oxygen chamber 115, or the air chamber 116, or with both the oxygen and air chambers. The air chamber 116 is formed in an upper side part of the case 21 and has an outer wall 118 having the form of a frame which is secured to the case by screws 119 and provided with an air inlet opening or port 120. Across the outer end of this port extends a fine screen 121 which admits air from the external atmosphere into the air chamber 116 but prevents the entrance of any dirt with the same, this screen being secured at its edge by solder in a rabbet on the outer side of the frame 118. The inner end of the air port 120 is surrounded by an annular air valve seat 122 which is adapted to be engaged over its entire periphery or surface by an air check valve member 123 for entirely closing the air port, or to be engaged by only one part of this valve member while other parts of the same are disengaged from this seat to permit ordinary air from the exterior to pass through this port into the air chamber 116. In order to render this air valve member very sensitive and open easily, when subjected to the suction of an inhalation by the user of the apparatus and also to close promptly during the exhalation of the wearer, this valve is made of very thin and light sheet material, such as mica, and this is supported by very delicate yielding means which respond quickly to the inhalation and exhalation of the person using the apparatus. The preferred means for mounting the air check valve member 123 to obtain this result are constructed as follows:

The numeral 124 represents an air check valve spring of helical form which has one end secured to the inner side of the air check valve 123 while its inner end is secured to a supporting spider mounted on this inner side of the case. This spring is made of small gage spring wire so that it is very sensitive and possesses sufficient resilience to hold this check valve closed during exhalation of the wearer using the apparatus but to open promptly and uncover the air port 120 when this check valve is subject to the inhalation suction of the wearer. This spring is also preferably so connected with this check valve that when the latter is not subject to inward suction pressure the same will be held in full contact with the check valve seat 122 and close the port, as

shown in Fig. 3, but when the air chamber 116 is subjected to inward suction, due to inhalation of the person being served, this check valve will be tilted and turned with an edge portion thereof in engagement with the valve seat 122 as a fulcrum while the other edge parts of this valve are moved inwardly from the corresponding parts of this valve seat 122, as shown in Fig. 11, and uncover the port 120 sufficiently to permit external air to flow through this port into the air chamber 116. A spider for supporting the check valve spring, as shown in Figs. 3, 8, 10 and 11, includes a ring shaped front section 125 which is secured to the inner side of the wall frame 118 by bolts 126, and a ring shaped rear section 127 which is off-set inwardly from the front spider section 125 and connected with the inner end of the check valve spring 124, and a plurality of arms 128 connecting said front and rear spider sections and formed therewith out of a single sheet of metal.

The inner end of the air chamber 116 is provided with a valve seat member 129 which contains a proportioning air port 130 leading from the air chamber 116 to the outlet or respiration chamber 117 and surrounded on its inner end by an annular proportioning air valve seat or seating portion 131. This member is secured at its marginal edge to an outwardly facing shoulder 132 on the adjacent part of the case by screws 133, a packing or gasket being interposed between this head and the case to produce a tight joint.

Opposite the air valve head 129 is arranged an oxygen proportioning valve seat member 134 which bears at its outer edge against the front end of an oxygen valve sleeve 135 which is adjustable lengthwise in a tubular guideway 136 in the upper part of the case and held in its adjusted position by a set screw 137 mounted on the case so as to be accessible from the exterior of the apparatus and bearing at its inner end against the side of this valve sleeve, as shown in Fig. 14.

The oxygen valve seat member 134 is provided with a central port 138 which, together with the bore of the valve sleeve 135, is adapted to form a conduit leading from the oxygen delivery chamber 27 to the outlet or respiration chamber 117 of the apparatus. On its front side the oxygen valve head is provided with an annular oxygen proportioning valve seat 139 around the oxygen port 138. The valve seat members 129, 134, and valve sleeve 135 are axially in line and the oxygen valve seat member is held in engagement with this valve sleeve in all positions of the latter by a comparatively heavy helical spring 140 interposed between the marginal parts of the air and oxygen valve seat members, as shown in Fig. 3.

Between the valve seat members 129 and 134 is arranged a proportioning valve 141 which preferably has the form of a flat disk constructed of mica and adapted to engage either the oxygen valve seat 139, as shown in Fig. 3, for cutting off communication with the oxygen delivery chamber 27 or to be arranged close to this valve seat 139 to permit only a small amount of oxygen to pass through the port 138 but permitting air to pass through the port 130 to the outlet chamber, or to engage the air valve seat 131 and cut off air but permitting oxygen to pass from the delivery chamber 27 and its extension 115 to the outlet or respiration chamber, or this proportioning valve may occupy a position between the valve seats or seating portions 131, 139 without engaging either of them and thus permit both air and oxygen to pass, respectively through the ports

130 and 138 to the outlet or respiration chamber 117.

The position of the proportioning valve 141 relative to the air valve seat or seating portion 131 and the oxygen valve seat or seating portion 139 determines the proportion of air and oxygen in the mixture which is supplied to the aviator or other person using this apparatus and this position of the proportioning valve is automatically shifted in accordance with the oxygen requirement of a person at different altitudes.

Adjusting means are therefore provided for shifting the proportioning valve 141 which are responsive to changes in atmospheric pressure at different altitudes and which also may be adjusted manually when setting up the apparatus and insure its operation in the most satisfactory manner. These adjusting means, as shown in Figs. 3, 9, 13-16, are preferably constructed as follows:

The numeral 142 represents a supporting tube which is arranged axially in line with the proportioning valve 141 and the air and oxygen valve seats or seating portions 131, 139 and is provided with an external screw thread 143 which works in a correspondingly threaded opening 144 in the adjacent part of the case 20 so that the inner end of this tube is arranged within the delivery chamber 27 and its outer end is arranged outside of this case. This supporting tube may be turned from the exterior of the case by a screw driver or similar tool engaging with a notch 145 in the outer end of this tube for adjusting the same lengthwise of its axis and after such adjustment the same together with the parts mounted thereon are held in position by a set screw 146 working in a threaded opening in the case and engaging its inner end with the side of this tube while its outer end is accessible from the exterior of the case for manipulation, as shown in Fig. 5.

The numeral 147 represents an aneroid tube the outer part of which is arranged within the inner part of the supporting tube 142 and connected therewith by a screwjoint 148.

Within the oxygen valve sleeve 135 and surrounding the inner part of the aneroid tube is an aneroid housing 149 the front end of which is open and forms a stop 150 and the rear end of which is provided with a supporting head 155 which is fastened to the supporting tube 142 and the aneroid tube 147 so as to be compelled to move with these tubes. This is preferably accomplished by clamping the head 155 of the aneroid housing between the inner end of the supporting tube 142 and a rear aneroid head 152 formed on the aneroid tube about midway of its length, as shown in Fig. 3.

The numeral 153 represents the bellows shaped body or diaphragm of an aneroid the rear end of which is connected with the relatively stationary rear aneroid head 152 while the front end of this bellows is connected with an axially movable front aneroid head 154. Contraction of the aneroid bellows is limited by engagement of the front aneroid head 154 with the front end of the aneroid tube 147, as shown in Fig. 3. The rear head 152 of the aneroid housing is provided with an opening 151 so as to permit the variation in the gas pressure surrounding this housing to act on the aneroid bellows and expand the latter when the apparatus operates in higher altitudes where the atmosphere is rarer and contract the same when the apparatus operates in lower altitudes where the atmosphere is denser. A relatively heavy spring 149 is arranged within the

aneroid bellows and interposed between its heads 152, 154 and assists in the expansion of this bellows.

The air is evacuated from the interior of the aneroid through an opening 157 in the side of the aneroid tube 147 leading from the interior of this bellows to the bore of the aneroid tube, and an evacuating tube 158 the inner end of which communicates with this bore and the outer end of which is sealed by solder 159 after evacuation of the aneroid has been effected.

The proportioning valve 141 is mounted on the front bellows head 154 by means which compel this valve to move with this head but permit the same to tilt and bear fully against the entire annular surfaces of the air valve seat 131 and the oxygen valve seat 139 upon engaging these seats. The means for this purpose which embody this invention are shown in Figs. 3, 9, 13-16 and are constructed as follows:

The numeral 160 represents an externally screw threaded stem projecting forwardly from the front aneroid head 154 and provided at its front end with a longitudinal supporting pin 161 which is of relatively small diameter and passes loosely through an opening in the center of the proportioning valve 141 so that the latter is free to rock on this pin.

Between the rear side of the proportioning valve 141 and the front end of the stem 160 a metal washer 162 is mounted loosely on the pin 161. The front end of this stem is made of convex or rounded form, as shown at 163 in Fig. 3 so as to permit the proportioning valve 141 to tilt thereon the requisite extent for engaging its marginal parts fully with either the proportioning air valve seat 131 or the proportioning oxygen valve seat 139 upon moving this valve into either its foremost or rearmost position. The proportioning valve and washer 162 are held in position on the pin 161 so that the same are normally at right angles to the axis of this pin and the stem 160 and still are capable of tilting slightly relative thereto. This is accomplished by a phosphor bronze spring retaining washer which has a square dished body 164 provided with a central hole 165 receiving the pin 161 and bearing with its convex rear side on the proportioning valve and four triangular wings 166 extending at an angle rearwardly from the several straight edges of this washer body and each wing engaging its tip with the front side of the proportioning valve, as shown in Figs. 3, 9 and 13. This spring retaining washer 164, 166 is held in engagement with the proportioning valve by a small metal split sleeve 167 which engages frictionally with the pin 161 and the front side of the washer body 164 and is adhesively held against displacement on the pin 161 by applying a coating 176 of varnish or the like to this pin preparatory to slipping this sleeve thereon. These means for mounting the proportioning valve on the aneroid stem permit this valve to automatically seat itself in fluid tight engagement with the air valve seat, even if the parts are not in accurate alinement, and it also prevents the oxygen from being diluted with air at or above an altitude of 34,000 feet. At the same time any tendency of the spring washer 164, 166 to distort the proportioning valve 141 is prevented by the washer 162. Moreover this organization performs the additional function of preventing the inner central face of the proportioning valve from becoming scratched which is very important for obtaining the greatest efficiency.

Stop means are provided for limiting the movement of the proportioning valve 141 toward the oxygen valve seat 139 and preventing the same from being engaged so firmly as would be liable to injure this valve during contraction of the aneroid. This is preferably accomplished by a disk shaped stop plate 168 which is arranged in front of the aneroid housing 149 and provided with a central hole which receives the stem 160 and a plurality of stop lugs 169 arranged equidistant in an annular row at its periphery and projecting rearwardly therefrom in position to engage the stop surface 150 on the front end of the aneroid housing 149, as shown in Figs. 3 and 14. Rearward adjustment of the stop plate 168 is effected by an adjusting screw nut 170 of the elastic lock type rotatable on the externally threaded front part of the aneroid stem 160 and engaging with the front side of this stop plate, as shown in Fig. 3. This stop plate is held in engagement with the adjusting nut 170 by a spring washer 171 mounted on the aneroid stem 160 and interposed between the rear side of this stop plate and the front side of the front aneroid head 154.

When this apparatus is used on the ground or low levels the aneroid is contracted to its greatest extent by the atmospheric pressure, whereby the proportioning valve 141 is drawn close to or against the seat 139 and oxygen is shut off completely, or almost completely, from the outlet or respiration chamber 117 and only air, or substantially only air, is admitted to this respiration chamber. The amount of oxygen admitted while the air port 130 is fully open is governed by the conditions under which the apparatus is used and the extent which the aneroid is permitted to contract at low altitudes.

When the apparatus is used in moderately high altitudes and the atmospheric pressure is reduced the aneroid expands in accordance with the rarification of the atmosphere, thereby causing the proportioning valve 141 to open the oxygen port 138 to a greater extent and close the air port 130 in the same measure, whereby both oxygen and air in diluted form are admitted to this outlet or respiration chamber 117 for use by the person being served. When the aviator reaches extremely high altitudes and the atmosphere is highly rarefied the atmospheric pressure on the exterior of the aneroid is lowered to such an extent that the same expands fully and moves the proportioning valve 141 so as to completely cut off entrance of air into the apparatus and permit only oxygen to flow through the outlet or respiration chamber to the aviator or other person using the apparatus.

In the preferred method of assembling this apparatus the stop plate 168 is adjusted by means of the stop nut 170 so that the proportioning valve always permits a slight amount of oxygen to enter the respiration chamber at ground or low levels but the stop plate moves away from the housing 149 and permits the proportioning valve 141 to open the oxygen port 138 more fully at an elevation of about 16,250 feet. The entire aneroid controlled air and oxygen valve mechanism is assembled as a complete unit on the case by screwing the main supporting tube 142, which carries the several members of this unit, in the opening 142 of the case until the proportioning valve 141 firmly engages the air valve seat 131 and corresponds to a drop in the air pressure to a point equivalent to an altitude of about 34,000 feet, and then this supporting tube is locked in position by the set screw 146.

The adjusting sleeve 135 is then pushed for-

wardly until the oxygen valve seat 139 is about one thirty second of an inch from the respective face of the proportioning valve 141, whereby the aviator will receive a mixture of air containing from 14 percent to 30 percent of oxygen at ground level up to an altitude of about 16,250 feet. These parts are then secured in this position by tightening the set screw 137.

Preparatory to using this apparatus the bottle or tank 35 is filled with oxygen under a relatively high pressure, say 500 lbs., by attaching the filler nozzle 69 with a suitable source of oxygen. When in use, the relatively high pressure oxygen passes up from the portable oxygen tank 35 through the inlet 37 to the reducing valve 48 which maintains a constant pressure in the low pressure or receiving chamber 26. Low pressure oxygen from the latter flows into the delivery chamber 27 whenever the wearer starts to inhale, assuming the oxygen port 138 to be open more or less, so as to cause the diaphragm 100 to be contracted or drawn inwardly and open the tilting demand valve 96. The proportioning valve 141 at low altitudes only permits a small amount of oxygen to flow from the main part of the delivery chamber to the outlet or respiration chamber 117, and thence through the usual corrugated hose and to the face mask which is provided with the usual exhalation valve. At low altitudes the wearer usually breathes, say 70 to 86 percent air which is sucked through the air port 130 after it passes through the air screen and has been reduced to the desired pressure in the respiration chamber 117 a sufficient extent to open the mica air valve 123 against the resistance of the spring 124. When the aviator has ascended to an altitude of say 16,250 feet, the aneroid expands, due to the pressure of the spring 156, thereby moving the proportioning valve into an increasingly open position, whereby the percentage of breathed air which is cut down and the percentage of oxygen taken in by the aviator is increased.

It is to be noted that the spring resistance to the opening of the air inlet valve 123 is higher than the spring resistance to the opening of the demand valve 96 so as to insure transfer of oxygen from the constant pressure chamber 26 to the delivery chamber 27 during inhalation by the user.

For the purpose of strengthening the air valve 123 and the air and oxygen proportioning valve 141 each of these valves is preferably made of two sheets of mica 172, 173 which are connected by a film 175 of cement between them so that the minor percussion axes or grain of these two sheets are arranged at an angle relative to one another; one sheet preferably having its minor percussion axis disposed at an angle of 90 degrees relative to the percussion axis of the other sheet. The manner of determining the percussion axes of the mica sheets is set forth in U. S. Patent No. 2,344,670.

When this apparatus is in use the same is preferably detachably connected with a harness worn by the aviator by a clasp 174 mounted on the rear part of the case.

I claim as my invention:

1. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite

ends of the diaphragm, an aneroid tube connected with the rear head of the aneroid, and provided with an external screw thread, an adjusting tube having an internal screw thread which receives the external thread of said aneroid tube and also provided with an external screw thread which engages with an internally threaded opening in the case, and a stem connected with the front aneroid head and operatively connected with said valve.

2. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the diaphragm, an aneroid tube connected with the rear head of the aneroid and provided with an external screw thread, an adjusting tube having an internal screw thread which receives the external thread of said aneroid tube and also provided with an external screw thread which engages with an internally threaded opening in the case, a stem connected with the front aneroid head and operatively connected with said valve, and a spring arranged within said aneroid bellows and interposed between said aneroid heads.

3. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the diaphragm, an aneroid tube connected with the rear head of the aneroid and provided with an external screw thread, an adjusting tube having an internal screw thread which receives the external thread of said aneroid tube and also provided with an external screw thread which engages with an internally threaded opening in the case, and a stem connected with the front aneroid head and operatively connected with said valve, the front end of said aneroid tube forming a stop which is adapted to be engaged by said front aneroid head for limiting the contraction of said aneroid bellows.

4. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the diaphragm, an aneroid tube connected with the rear head of the aneroid and provided with an external screw thread, an adjusting tube having an internal screw thread which receives the external thread of said aneroid tube and also provided with an external screw thread which engages with an internally threaded opening in the case, and a stem connected with the front aneroid head and operatively connected with said valve said aneroid tube having an opening which establishes communication between the interior of said aneroid bellows diaphragm and said aneroid tube and the rear end of said aneroid tube being provided with a sealable evacuating tube.

5. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward

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and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the bellows diaphragm, means for mounting the rear aneroid head on the case, and means for mounting the valve member on the front aneroid head including a stem projecting forwardly from the front aneroid head and having a supporting pin passing through said valve and also provided with a convex face at its front end, a rear washer interposed between said convex face and the rear side of said valve member, and a front washer mounted on the pin and engaging with the front side of said valve member.

6. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the bellows diaphragm, means for mounting the rear aneroid head on the case, and means for mounting the valve member on the front aneroid head including a stem projecting forwardly from the front aneroid head and having a supporting pin passing through said valve and also provided with a convex face at its front end, a rear washer interposed between said convex face and the rear side of said valve member, and a front washer mounted on the pin and engaging with the front side of said valve member said front washer having a rectangular head provided with an opening which receives said pin and tapered wings engaging said valve member.

7. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the bellows diaphragm, means for mounting the rear aneroid head on the case, and means for mounting the valve member on the front aneroid head including a stem projecting forwardly from the front aneroid head and having a supporting pin passing through said valve and also provided with a convex face at its front end, a rear washer interposed between said convex face and the rear side of said valve member, and a front washer mounted on the pin and engaging with the front side of said valve member said front washer being constructed of spring material and having a rearwardly dished head the convex side of which engages said valve member and a plurality of rearwardly inclined tapering wings which engage with the front side of said valve member.

8. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the bellows diaphragm, means for mounting the rear aneroid head on the case, and means for mounting the valve member on the front aneroid head including a stem projecting forwardly from the front aneroid head and having a supporting pin passing through said valve and also provided with a convex face at its front end, a rear washer interposed between

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said convex face and the rear side of said valve member, a front washer mounted on the pin and engaging with the front side of said valve member, and means for retaining said front washer in place including a retaining sleeve which is frictionally secured to said pin.

9. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, an aneroid having a bellows diaphragm and front and rear heads at opposite ends of the bellows diaphragm, means for mounting the rear aneroid head on the case, and means for mounting the valve member on the front aneroid head including a stem projecting forwardly from the front aneroid head and having a supporting pin passing through said valve and also provided with a convex face at its front end, a rear washer interposed between said convex face and the rear side of said valve member, a front washer mounted on the pin and engaging with the front side of said valve member, and means for retaining said front washer in place including a split sleeve frictionally gripping said pin and engaging said valve member and a film of cement interposed between said sleeve and pin.

10. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, and means for actuating said valve member including an aneroid having a bellows diaphragm and front and rear heads at opposite ends of said bellows diaphragm, means for supporting said aneroid on the case including a tube connected within the rear aneroid head, means for connecting said aneroid with said valve member including a stem projecting forwardly from the front aneroid head, and means for limiting the movement of the valve member toward said seat upon contraction of said aneroid.

11. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, and means for actuating said valve member including an aneroid having a bellows diaphragm and front and rear heads at opposite ends of said bellows diaphragm, means for supporting said aneroid on the case including a tube connected with the rear aneroid head, means for connecting said aneroid with said valve member including a stem projecting forwardly from the front aneroid head, and means for limiting the movement of the valve member toward said seat upon contraction of said aneroid, including a housing enclosing said aneroid and mounted on the aneroid tube, and a stop plate mounted on said stem and adapted to engage said housing.

12. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, and means for actuating said valve member including an aneroid having a bellows diaphragm and front and rear heads at opposite ends of said bellows diaphragm, means for supporting said aneroid on the case including

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a tube connected with the rear aneroid head, and an adjusting tube having screw threaded connections with said aneroid tube and said case, means for connecting the aneroid with said valve member including a stem projecting forwardly from the front aneroid head and operatively connected with said valve member, and means for limiting the movement of the valve member toward said seat upon contraction of said aneroid including a housing having a tubular body surrounding said aneroid and having a rear head secured between said rear aneroid head and the front end of said adjusting tube and provided at its front end with a stop, a stop plate mounted on said stem and adapted to engage with said stop, a screw nut arranged on said stem and engaging the front side of said stop plate, and a spring washer interposed between the rear side of said stop plate and the front aneroid head.

13. A breathing apparatus comprising a case having a gas delivery chamber and a respiration chamber, means for conducting gas from said delivery chamber to said respiration chamber having a valve seat, a valve member movable toward and from said seat, and means for actuating said valve member including an aneroid having a bellows diaphragm and front and rear heads at opposite ends of said bellows diaphragm, means for supporting said aneroid on the case including a tube connected with the rear aneroid head, and an adjusting tube having screw threaded connections with said aneroid tube and said case, means for connecting the aneroid with said valve member including a stem projecting forwardly from the front aneroid head and operatively connected with said valve member, and means for limiting the movement of the valve member toward said seat upon contraction of said aneroid including a housing having a tubular body surrounding said aneroid and having a rear head secured between said rear aneroid head and the

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front end of said adjusting tube and provided at its front end with a stop, a stop plate mounted on said stem and adapted to engage with said stop, a screw nut arranged on said stem and engaging the front side of said stop plate, and a spring washer interposed between the rear side of said stop plate and the front aneroid head, said stop plate being provided with a plurality of stop projections on its rear side for engagement with said stop.

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